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Properties of three gas-rich dwarfs in the Centaurus A group

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Abstract. We present HST/WFPC2 observations (F555W, F814W) and ATCA high resolution HI maps of three gas-rich dwarf galaxies in the Centaurus A group discovered in two blind 21-cm surveys (HIPASS, HIDEEP). We compare their individual properties and discuss their star formation history. Although we can not constrain the age of the oldest population from the diagrams very well, the presence of an extended population of red giant stars suggests that these systems were not formed recently. The presence of asymptotic giant branch (AGB) stars in two out of three dwarfs, sets a lower limit on the age of about 6 Gyr.

1. Introduction

The dwarf galaxies in the Local Group (LG) present a wide range of star formation histories, gas fractions and metallicities and are usually divided in two main classes. On the one hand gas-deficient, low mass and luminosity dwarf spheroidal (dSph) galaxies, generally found within 300 kpc of the more massive group members. On the other, gas-rich dwarf irregular (dIrr) galaxies have a larger range in both mass and luminosity and a less clustered distribution. The richness in gas of a galaxy is defined by the ratio between its HI mass and B luminosity, expressed in solar units (M_{HI}/L_B). Late-type dIrr in the LG have $M_{HI}/L_B \lesssim 1$. However galaxies with $M_{HI}/L_B > 1$ can be found in nearby groups, indicating that a large amount of their gas content has not yet been processed into stars (Côté et al. 1997; Banks et al. 1999; Karachentsev, Karachentseva, & Huchtmeier 2001). Are they recently formed objects? Or rather systems where star formation (SF) is not efficient? If so, what inhibits SF in these environments?

Table 1. Observed properties of the Centaurus A dwarfs

Object	$v_\odot$ km s^{-1}	M_B	$M_{HI}/M_\odot$	M_{HI}/L_B	d Mpc	D$_{M83}$ Mpc
HIPASS J1337-39	490	-11.9	3.7×10^7	3.1	4.9	0.9
HIDEEP J1337-33	590	-10.7	5.0×10^6	1.4	4.5	0.3
HIPASS J1321-31	570	-11.5	3.7×10^7	5.1	5.2	0.8

To investigate these issues we have selected three gas-rich dwarfs found in two blind 21-cm surveys, the HI Parkes All-Sky Survey (HIPASS)in the Centaurus A group (Banks et al. 1999) and HIDEEP (Minchin et al. 2003). They have faint luminosities ($M_B \sim -11$) and low surface brightness ($\mu_B > 24$ mag arcsec^{-2}) typical of LG dSphs but with M_{HI}/L_B higher than the average value for LG dIrrs (see Table 1). Thus, despite their substantial amount of gas, that would make them favoured hosts for starbursts, their star formation rates (SFRs) tend to be low ($\lesssim 10^{-3} M_\odot yr^{-1}$). Being in one of our closest groups, their stellar population can be resolved with the use of the Hubble Space Telescope. We present such WFPC2 follow-ups and high resolution 21-cm maps taken with the Australian Telescope Compact Array (ATCA).

2. Observations

The objects were followed-up with ATCA in two different runs in 2001, using the 750-D and 1.5 km array configurations. The total integration time per source in each configuration was 12 hours. In June 2001 the three dwarfs were observed with the WFPC2 in two filters (F555W and F814W) for 5000 s and 5200 s respectively. Details about the observations and data reduction can be found elsewhere (Pritzl et al. 2003, Grossi et al. 2003 in prep.).

3. Results and discussion

3.1. Constraining the age of the old stellar population

The dwarfs show a well developed red giant branch (RGB) which indicates that the dominant stellar population consists of intermediate-old age stars. Stars with a wide range of ages overlay in this area of the diagram making it very difficult to derive the star formation history from only this feature. Thus, to constrain the ages of these galaxies we can only use the AGB stars, indicators of the intermediate-to-old age stellar population (less than 10 Gyr). There is evidence of stars that lie above the tip of the RGB (at $1.0 < V - I < 1.3$) in **HIPASS J1337-39** (Fig. 1). The lack of stars in the field with that range of colors and magnitudes suggests that these are AGB stars in J1337-39. Theoretical isochrones from the Padua group (Girardi et al. 2002, Bertelli et al. 1994) can match the position of these stars assuming an age of $\sim$ 6 Gyr and a metallicity of Z= 0.0004 (1/50 solar). A few AGB candidates can also be identified in **HIDEEP J1337-33** although less numerous than in J1337-39. Again comparison with stellar tracks gives an age of $\sim$ 6 Gyr for a metallicity Z = 0.001 (1/20 solar). **HIPASS J1321-31** does not seem to show evident AGB

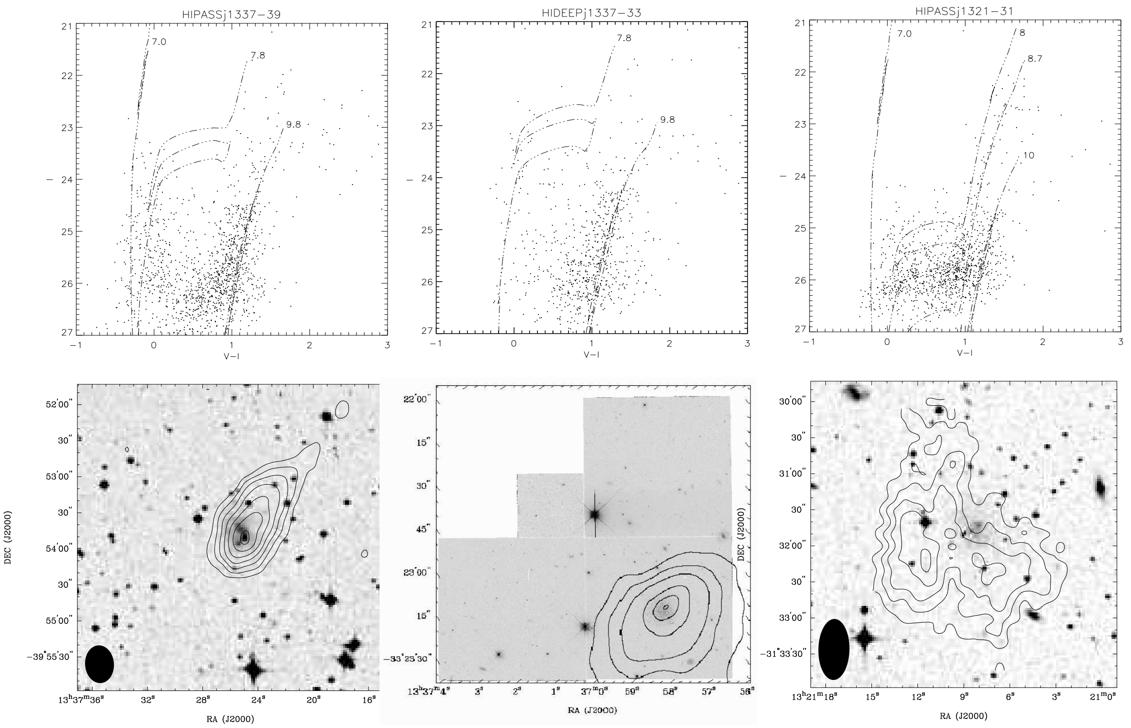

Figure 1. **left)** HIPASS J1337-39: **up)** (V-I), I color magnitude diagram with Padua group theoretical isochrones overlaid at z=0.0004 (1/50 solar). The numbers indicate the corresponding log *Age*. **down)** Hi column density contours overlaid on the DSS image of the field. Levels: 2.5, 5.0 7.5, 10, 12.5, 15.0, 17.5 $\times 10^{20}$ cm^{-2}. **center)** HIDEEP J1337-33: **up)** (V-I), I color magnitude diagram with Padua isochrones at z=0.001 (1/20 solar). **down)** Hi column density contours overlaid on the WFPC2 field. Levels: 0.5, 1.0 1.5, 2.0, 2.25, 2.35 $\times 10^{20}$ cm^{-2}. **right)** HIPASS J1321-31: **up)** (V-I), I color magnitude diagram with Padua stellar tracks at z=0.0004. **down)** Hi column density contours overlaid on the DSS field. Levels: 0.5, 1.0 1.5, 2.0, 2.5 $\times 10^{20}$ cm^{-2}.

stars. However its color magnitude diagram (CMD) presents a peculiar bright ‘red plume’ extending up to I $\sim$ 22.6. We have ruled out the possibility of this being the RGB of the galaxy (Pritzl et al. 2003) and we believe that it is more likely related to recent ($\lesssim$ 1 Gyr) SF activity in this galaxy. We briefly discuss our interpretation in the next section.

3.2. The more recent SF activity and the gas distribution

HIPASS J1337-39 is the only galaxy which is currently forming stars as one Hii regions can be found in the southern part of the galaxy. The region correlates with the peak in the Hi column density ($N_{H\mathrm{I}} = 2{\times}10^{21}$ cm^{-2}), the highest among the three dwarfs. The well developed blue plume at $(V - I) < 0.2$, indicates a population of core-helium burning stars with an age of 60-100 Myr (Fig. 1). The small number of blue stars (at -0.2 $< V - I <$ 0.5) in **HIDEEP J1337-33** and the absence of evident Hii regions indicates a drop in the star formation activity

at around 60 Myr (Fig. 1). The neutral gas density in the optical extension of the galaxy is almost constant, hovering around $N_{H\text{I}} = 2 \times 10^{20}$ cm^{-2}. There is no evidence of very recent SF in **HIPASS J1321-31** either. However the thin red plume in its CMD indicates a peculiar star formation history (SFH). We have proposed that it consists of core-helium burning stars in the red super giant (RSG) phase (Pritzl et al. 2003). This scenario would imply that the galaxy went through a period of enhanced star formation activity less than 1 Gyr ago. The more massive stars would have already vacated the blue spike while the RSG branch would presently be inhabited by $\lesssim 3M_{\odot}$ stars, possibly 500 Myr old assuming a metallicity of 1/50 solar (Fig. 1). To explain the presence of the faint blue stars, the SF activity must have continued after the burst at a decreasing rate, and dropped off around 100 Myr ago. The HI distribution (Fig. 1) is offset from the optical center with an overall low gas column density whose peaks (at $N_{H\text{I}} = 2.5 \times 10^{20}$ cm^{-2}) do not seem to be related to the main optical counterpart.

4. Conclusions

We can rule out the possibility that the HIPASS dwarfs in Cen A are recently formed objects as indicated by the presence of a population of RGB and AGB stars. However the issue of their low star formation rates is still open. The overall low gas column density, apart from sporadic local enhancements, may be one possible explanation, although we can not exclude connections with the local environment. M83 is the closest massive galaxies to the dwarfs, but only HIDEEP J1337-33 is within 300 kpc from it (see Table 1). On the one hand the lack of interactions may prevent massive SF from occuring in the more isolated dwarfs like J1337-39 or J1321-31. On the other, gas-stripping may be responsible for the current quiescence of J1337-33, a possible satellite of M83.

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